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Planning Considerations in Vegetation Management

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Planning Considerations in Vegetation Management

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Preface

This manual is intended for persons in charge of vegetation control on federal land in the aspen parkland and boreal mixedwood ecoregions. Its purpose is to aid in planning vegetation management programs to suit the land uses and environmental conditions of the management area. It should be used as a supplement to, not a substitute for, instructional books on vegetation management.

Within the area for which this manual is intended, soils and growing conditions vary, and local experts should always be consulted on methods, rates of application, and equipment. Additionally, however, the manager should be aware of all the options available in order to design vegetation management programs that are not only cost-effective but also environmentally and socially acceptable.

Table of Contents

	Preface	i
	Table of Contents	ii
	Introduction	1
1.	**General Considerations in Environmental Protection**	3
	Selectivity	3
	Non-target Effects	4
	Sources of Information	6
2.	**Special Areas**	7
	Land Uses	7
	Environmentally Sensitive Areas	11
3.	**Timing and Prevention**	16
	Timing	16
	Weed Prevention on Newly Developed Sites	17
4.	**Mechanical and Manual Methods**	19
	Mechanical Methods	19
	Manual Methods	21
5.	**Biological Control Methods**	23
	Biological Control of Weeds by Insects and Pathogens	23
	Grazing	24
6.	**Controlled Burning**	26
7.	**Chemical Methods**	28
	Herbicide Selectivity	28
	Herbicide Formulations and Products	28
	Application Methods	29
	Growth Retardants	33
8.	**Chemical Precautions**	35
	Environmental Safety of Pesticides	35
	Off-site Movement	37
	Herbicide Persistence	41
	Toxicity to Animals	41
	Clean-up and Disposal	43

9. Developing a Vegetation Management Plan 45
Established Sites 45
Newly Developed Sites 47

10. General Reference 50
Contacts 50
Reference Material 52

Appendices
A. Susceptibility of Woody Species to Some Herbicides
B. Herbicide Behaviour in the Environment
C. Mechanical, Competitive and Biological Weed Control Methods
D. Growth Habits of Some Common Weeds
E. Potential for Regrowth of Woody Species
F. Herbicide Classification

Introduction

A vast array of methods, equipment and chemicals is available today for managing vegetation. Selecting the most suitable one or combination for your situation can be challenging. As a manager of vegetation on public land, you may be in charge of areas whose multiple functions are unrelated, such as rights-of-way through parks or wildlife habitat on military reserves. Similarly, the land adjacent to your management area may have a totally different use.

To design vegetation management programs for such diverse situations, you may need to take environmental and societal considerations into account. This in turn requires a knowledge of the options available to you, as the conventional way of doing things may not be the most suitable for a particular situation.

At the same time, you have to balance the three factors of **cost**, **effectiveness**, and **environmental protection**. Many "how-to" manuals deal with the first two. This manual will help you build environmental and societal considerations into your vegetation management strategy. Ignoring these factors may result in harm to the environment and avoidable costs to the managing agency and to society.

The manual is organized into the following sections:

1: **General Considerations in Environmental Protection**-
some basic tools and ideas for protecting the environment

2: **Special Areas**-
areas which require special treatment because of environmental, societal or land-use considerations

3: **Timing and Prevention**-
timing for control and preventive management measures

4-7: **Mechanical and Manual Methods, Biological Control, Controlled Burning** and **Chemical Methods**-
types of vegetation control methods available

8: **Chemical Precautions**-
ways to ensure environmental protection when using herbicides and fungicides

9: **Developing a Vegetation Management Plan**-
how to formulate a vegetation management plan suited to site conditions

10: General Reference- contacts and references for further information on various aspects of vegetation management

Readers who are relatively new to the subject should begin with **Chapter 9** for an overview of the vegetation management planning process. Then use **Chapters 1-3** and **8** to define or refine your vegetation management objectives and identify your inventory needs. Last, examine and compare the methods available to you using **Chapters 4-7** and the contacts listed in **Chapter 10**.

1 General Considerations in Environmental Protection

The basic vegetation control methods available to the vegetation manager are:

- mechanical control
- chemical control (herbicides and fungicides)
- biological control
- cultural (competitive) control, and
- controlled burning.

All of these methods are capable of altering the environment. The degree to which they do so is up to you. How selective can and should your methods be? How can unwanted ecological effects be avoided? This chapter examines these questions.

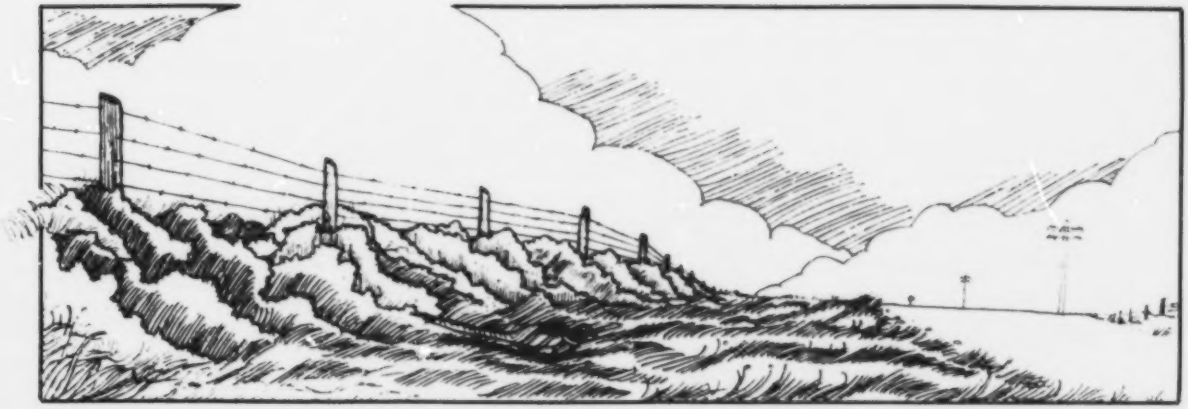
Selectivity

Selective vegetation control methods or materials affect the plant species for which the control is intended (**target species**) while leaving other (**non-target**) species unaffected. Methods differ in their degree of selectivity. For example, mechanical methods such as mowing may be fairly non-selective, since all vegetation in the mower's path over the height of the blade is cut. With chemical methods, selectivity depends on the herbicide, application method, and other factors. Biological control methods utilizing insects or pathogens are highly selective.

In addition to the method used, the timing of a treatment can confer selectivity. For example:

- Damage to honeybees from certain herbicides can be avoided by spraying in cool, late evenings or early mornings when the bees are in the hives (see page 41).
- Destruction of the eggs and young of ground-nesting game birds can be avoided by mowing grass after mid-July.
- Spraying after adjacent crops have been harvested avoids damage to desirable plants.

When the vegetation on the site contains a large proportion of desirable (non-target) species, it is often best to use a very selective treatment. This leaves the plant community intact, rather than opening it to invasion by weed species. As well, it preserves



the ecological integrity of the site. Some specific environmental and land use situations which require selective treatment are described in Chapter 2.

Selective methods may be more expensive initially than non-selective methods but may reduce maintenance costs over the long term. For example, along Wisconsin roadsides, manual removal of unwanted types of shrubs allowed desirable types to spread. The high initial cost of this treatment was offset by reduced long-term maintenance costs.[1]

Non-target Effects

Non-target effects are effects on plants or animals other than those for which the treatment was intended. Methods differ in their potential for non-target effects.

Non-target effects of herbicides on terrestrial wildlife are primarily the result of changes to the vegetation community rather than toxicity. Most herbicides are of low acute toxicity to most terrestrial animals at registered application rates. However, some herbicides are acutely toxic to aquatic wildlife such as fish and small invertebrates and can harm aquatic ecosystems if allowed to enter water (see page 42).

Non-target effects can also result from mechanical methods. For example, brush-mowing a right-of-way in early summer may destroy nesting sites of some types of birds. Heavy equipment that disturbs soil may cause sediment to accumulate in aquatic habitats.

The significance of such non-target effects is not always easy to estimate. From an ecological perspective, the destruction of five

bird's nests by roadside mowing may be insignificant in the case of an abundant species and significant in the case of an uncommon species. On the other hand, the value of wildlife to nearby residents may be quite unrelated to the ecological significance of the species.

Avoiding Non-target Effects

Obviously, the vegetation manager seeks to avoid non-target effects whenever possible. Choosing the most selective treatment possible is one means. In addition, if you are using a chemical method:

- Use the least toxic pesticide (herbicide/fungicide) that will achieve the intended result.
- Read all precautions on the pesticide label **in advance**.
- Make sure that your application equipment is properly calibrated.
- Reduce the possibility of off-site movement of the pesticide (see Chapter 8).

Whatever methods you select, ensure that your field staff is well-trained. **The environmental awareness of the persons carrying out the treatment is a crucial aspect of environmental protection.** Your careful planning can be undermined by field personnel who fail to exercise caution around sensitive areas. For example, operators of heavy machinery can create soil erosion problems on slopes. Pesticide applicators can cause damage with herbicides, as occurred when the spraying of a roadside with 2,4-D and 2,4-DP contaminated a ditch connected to a trout pond.[2]

Impacts on Wildlife Habitat

In general, where vegetation management increases the diversity of plant types present, such as a right-of-way through a forest, the area is improved for a number of wildlife species. Inducing shrub and tree regrowth likewise benefits some species.

On the other hand, vegetation management may reduce plant diversity - for example, by removing shrubs from the edges of cleared fields - thereby reducing wildlife habitat. Also, improved access to hunters along new rights-of-way through forests may negate any benefits created.

Enhancing wildlife habitat can sometimes be incorporated into the objectives for a site with little additional effort. For example, along an interstate highway right-of-way in North Dakota, mowing once every third year (instead of yearly) allowed the number of nesting ducks to increase significantly.[3] Manuals on this subject are listed in Chapter 10.

Sources of Information

Vegetation management draws on knowledge from many disciplines - botany, weed science, ecology, horticulture, entomology, and wildlife biology, to name a few. No one can be an expert in all these fields. Consult regional biologists, botanists, weed control experts, chemical manufacturers, reclamation experts, and others for any specific information you need. Some helpful contacts and reference material are listed at the end of the manual.

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2 Special Areas

Some environments and land uses require special vegetation management measures for reasons of aesthetics, environmental protection, public safety, or public relations. These situations and some special measures that have been used successfully to accommodate them are described below.

Land Uses

Most land use situations requiring special measures involve either:

- areas receiving intensive public use, or
- adjacent sensitive areas.

Scenic or Highly Visible Areas

Considerations:

In scenic areas open to public view, such as parks and highways, the visual aspect is important. The following should generally be avoided:

- large amounts of dead foliage or trees
- visually-dominating, man-made contrasts in vegetation (for example, a large right-of-way on a hillside) in scenic natural areas.

Special measures:

- Trees or shrubs over 1.5 m in height on rights-of-way adjacent to a highway and over 2.5 m in height adjacent to a paved road are usually cut rather than foliar-sprayed.[1] The stumps may then be treated with herbicide to prevent regrowth (see page 32).
- To screen intersections of rights-of-way with roads, a strip of trees may be left or transplanted.
- To decrease the visual contrast between rights-of-way and surrounding treed areas, woody species are sometimes left under powerlines where they do not hinder access. Conifers are sometimes topped, or even allowed to grow as part of a tree nursery or as Christmas trees and sold when reaching a certain height.

Turf Areas

Considerations:

Some people are concerned over the possible exposure of children to pesticides on treated turf. Many fungicides are highly toxic and

cautions on the label must be strictly followed. Several ways to reduce exposure to herbicides and fungicides are described below.

Special measures:

- Water turf two days after herbicide treatment if rainfall has not occurred. Water will carry the residual chemical down into the soil.[2]
- Use granular formulations of herbicides if available. These lodge in the soil rather than on the grass foliage.[2]
- Post notice of chemical treatment.
- Treat at times of low public use.
- Use turf management programs that decrease dependence on herbicides. These usually involve an assessment of the acceptable amount and type of weeds based on the turf's function (e.g. picnicking vs. ball playing field). Measures to improve grass vigour, such as raising mowing height to about 7.5 cm, fertilization, and aeration are also included.[3]
- Employ measures to prevent fungal diseases. For snow mould, these include avoiding excessive moisture on turf in late fall and early spring by removing leaves and thatch; fall mowing:

hastening spring snowmelt; and avoiding use of nitrogen fertilizer in fall (see references in Chapter 10: Fungicides for Turf).

Berry-picking Sites

Considerations:

Public concern is sometimes expressed about herbicide residues on sprayed wild berries. Residues of 2,4-D and other herbicides sprayed on immature fruit may still be present on the berries when ripe.[4] It is unlikely that wild berries would be washed.

Special measures:

- If possible, delay treatment of popular picking sites until after the harvest period. Residues from a fall application will not persist into the next growing season.
- Post signs in the area if spraying prior to the picking season.

Adjacent Public Recreational Areas

Considerations:

Buffer zones in which herbicide spraying is not permitted are in effect around some provincial recreational lakes, campgrounds, and other recreational areas. These zones may vary in width from location to location.

Special measures:

- Check with provincial authorities.
- Post notices on herbicide-treated areas adjacent to these buffer zones.
- Take all precautions to avoid indirect contamination of these zones (see Chapter 8).

Adjacent Agricultural Areas

Considerations:

Crop, garden, and shelterbelt damage from off-site movement of herbicides has been the subject of numerous litigation and insurance claims. Herbicide drift, run-off and contamination of water supplies used in greenhouses have been the major complaints.

Special measures:

- Employ drift-reducing measures and observe weather conditions when spraying near crops, gardens and shelterbelts (see page 37). Use extreme caution near highly susceptible crops such as canola or field peas.
- Leave an untreated zone between agricultural fields and herbicide-treated areas.

- Discuss spraying schedule with owners of adjacent land.
- Apply herbicides using dormant-season formulations after crops have been harvested (see page 31).
- Use spot treatments.
- Use mechanical methods.
- Do not apply herbicide to areas of potential run-off into sloughs, dugouts or ditches used for watering crops.
- Be able to recognize herbicide-caused injury to plants (see references under Herbicides in Chapter 10) and be prepared to offer compensation in the case of serious damage.

Residential Areas

Considerations:

Because of the presence of gardens and ornamental trees, residential subdivisions and areas near farmhouses are treated with the same precautions as agricultural areas. Also, alternatives to broadcast foliar spraying are preferred by some residents.

Special measures:

- Mow.
- Spot treat with liquid or granular herbicide formulations.
- Use selective tree removal or topping at intersections and under powerlines.
- For herbicide use near shelterbelts, see also Commercial Timber Management Areas below.
- Discuss plans with residents.
- In all instances, avoid direct spray contact with people.

Commercial Timber Management Areas

Considerations:

Commercial timber can be damaged by drift from some brush and weed control herbicides (see Appendix A). Also, the growth of crop trees may be retarded by altered drainage on adjacent land.

Special measures:

- Employ drift control measures (see page 38).
- Where crop trees are conifers, use herbicides that control hardwoods and do not injure conifers (see Appendix A). Be willing to accept a lower degree of control in order to avoid non-target effects on crop trees.
- When applying herbicides to the soil, maintain a minimum horizontal buffer zone of 1-1/2 times the height of adjacent non-target trees to avoid root pick-up.

- Employ non-chemical methods.
- When clearing land adjacent to commercial timber, avoid altering drainage patterns.

Environmentally Sensitive Areas

Certain kinds of areas are particularly vulnerable to ecological damage from vegetation maintenance practices, as described below. Things to look for when assessing site sensitivity are listed in Chapter 9 (Developing a Vegetation Management Plan).

Slopes

Considerations:

Steep slopes require special care to ensure that they retain adequate vegetation, without which erosion will occur. Heavy machinery compacts soil, causing water erosion even on moderate slopes.

Special measures:

- Remove as little vegetation as possible.
- If trees or shrubs must be cut, leave the roots to hold soil, as these can prevent erosion better than grass.
- Minimize use of heavy machinery.
- If using chemical methods, choose herbicides that are not likely to run off or be picked up by roots (see Chapter 8).
- Revegetate bare areas at once.
- If erosion occurs, institute erosion control measures at once.

Other Erosion-Prone Areas

Considerations:

Access trails and areas that are repeatedly travelled by vegetation maintenance vehicles can become severely eroded. Sparse ground cover and clay soils are conditions that invite rutting and erosion from repeated trips.

Special measures:

- Keep bare areas reseeded.
- Minimize the number of trips over the area.
- Use tracked or light-weight vehicles such as trikes.
- Conduct operations in winter.
- Conduct manual or aerial operations.

Vegetation-free Areas

Considerations:

Some sites are kept vegetation-free for a number of years and then returned to agricultural use. Restoring agricultural capability to

barren soil can be difficult, requiring soil amendments over many years.[5] On some industrial lease sites where residual non-selective herbicides have been used for many years, reclamation measures are lengthy and expensive.[6]

Special measures:

- Keep accurate records of treatments to avoid overapplication of residual herbicides.
- Use physical barriers to plant growth such as asphalt, commercial geotextile covers, etc.
- Use mechanical means of vegetation maintenance (grass whips, etc.).
- Alternate a combination of methods, such as short-lived herbicides (Appendix B) and mechanical methods.

Areas Near Water

Considerations:

Areas near water are sensitive to vegetation control in the following ways:

Vegetation in and around ponds and sloughs of the prairies and parklands provides food and nesting cover for up to one-half of the waterfowl of North America.

- Tall, dense grass, shrubs, and forbs around sloughs are essential for nesting cover.[7]
- Aquatic vegetation is fed upon by ducks and also supports the insects fed upon by ducklings.[8]

Without special care it is difficult to avoid contaminating these areas during aerial treatment.

Streambank vegetation

- filters out sediment and contaminants (including herbicides) that would otherwise enter the water
- prevents erosion of streambanks
- provides shaded areas essential to good fish habitat
- harbours insects upon which fish depend, and
- provides travel corridors and shelter for wildlife.

Muskegs and bogs can accumulate pesticides and subsequently contaminate nearby streams.[9]

Fish and other aquatic life are susceptible to some herbicides (see page 42).

Special measures:

- Observe herbicide buffer zones established around streams and waterbodies (for example, 30 horizontal metres - Alberta; 50 m - federal parks). Use the selective control methods permitted by the provinces within these zones.
- Avoid direct spraying of small sloughs and marshy areas.

- On slopes that drain into wet areas, use non-chemical methods or herbicides that are not likely to leach or run off (Appendix B).
- Construct ditches to retain run-off around facilities on slopes.
- Leave natural vegetation around sloughs wherever possible.

Rangeland

Considerations:

Rangeland may be invaded by aggressive weeds, plants that are poisonous to cattle, or brush that shades out cattle forage. On the other hand, rangeland brush provides shelter for domestic and wild animals, retains snow that provides soil moisture, and prevents soil erosion. Rangeland may also contain relatively rare native plants and animals and/or critical habitat for wildlife. These important rangeland habitats are all too often eliminated by large-scale vegetation alteration.

Special measures:

- Plan rangeland vegetation control on an ecological basis, considering all functions of the land.* Consult with wildlife biologists and range management specialists.
- Consider grazing or grazing/spraying combinations (see page 24).
- Consider insect biocontrol for those weeds for which it is available (see page 23).
- Avoid overgrazing.

"Wasteland"

Considerations:

Native plant species often grow on unused land. Once eliminated from an area, some of these species may not re-establish. Their role as native seed sources, pollen sources, and habitat for insect enemies of crop pests and for wildlife is vital to a stable environment.

Special measures:

- Leave natural areas untreated where possible.
- Use spot treatment.

* If domestic grazing is intended, note that herbicides registered for non-crop or industrial use cannot be applied to land used for grazing unless specifically registered for this purpose. Note also that temporary grazing restrictions exist for some herbicides registered for pastureland; consult herbicide label or annual provincial agriculture weed control guide.

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3

Timing and Prevention

Timing

Good timing is essential for an effective treatment, be it chemical, mechanical or biological. With proper timing, you can:

- attack the plant at the weakest point in its life cycle or stage of growth
- prevent viable seed from being produced (herbaceous species).

To determine the proper timing, you need to identify the species with which you are working. Regional or provincial agricultural extension personnel (see Chapter 10) can help with the identification of all plant species, even weeds at early stages of development, and can provide information regarding seed-setting dates in your area. Plant samples can be stored in plastic bags in the freezer prior to identification or can be put in a plant press. When collecting a sample, try to obtain flowering parts, seeds, and roots along with the rest of the plant.

Herbaceous Species

Being aware of the life cycles of various plants will help you determine the best timing for weed control measures.

- **Annuals (summer and winter):** Summer annuals sprout, grow, and set seed by winter. Winter annuals sprout in fall and overwinter as low, flat rosettes that mature the following spring. Annuals are easiest to control by either chemical or mechanical means at the **early stages**. During the later bud, flowering and seed stages, control measures become progressively less effective.
- **Biennials:** Biennials require 12-24 months to grow to maturity and are best controlled **just before frost**.
- **Perennials:** Perennials live for over two years. They have underground root systems whose food reserves vary over the growing season. Control is most successful during the bud stage, when root reserves are lowest. It is also effective during the early seedling stage and, if regrowth occurs, just prior to frost or the following spring. If mowing is used, it must be repeated for several years at the proper time to deplete the root reserves and prevent seed production. Not all perennial weeds can be controlled in this manner (see Appendix C).

Appendix D gives some examples of weeds for each of the above growth cycles. Consult local or provincial agricultural extension personnel for the recommended timing of treatment for any particular species.

Woody Species

The most effective time to eliminate trees and shrubs by means of foliar herbicide application is generally considered to be immediately after full leaf development of the species to be controlled.[1] Young saplings and shrubs are easier to control by foliar spray than are older ones.

With mechanical methods, resprouting can be expected for most species, as shown in Appendix E. Subsequent treatments can be:

- repeated brushmowing (page 20)
- herbicide applied to the remaining stumps (page 32), or
- foliar spraying of regrowth.

In the latter case, spraying is done when there is sufficient foliar mass to absorb enough herbicide for an adequate kill (generally two to three years, depending on growing conditions).

The time of cutting may influence the amount of resprouting that occurs. Cutting in late summer is generally held to be best for most species. For western snowberry *(Symphoricarpos occidentalis)*, a combination of brushmowing in mid-summer and foliar spraying the following spring has been found to give good control.[2]

Weed Prevention on Newly Developed Sites

Preventing weeds from becoming established following soil disturbance is the least costly means of control. Preventive measures include the following:

- Use seed that is free of certain noxious weeds. Even certified or registered seed has some weed seeds. Request a certificate of analysis to identify the numbers and kinds of weed seeds present in the seed. Local agriculture extension personnel can tell you which ones should be avoided.
- Use heavy seeding rates (25% higher than normal) to outcompete weeds, except in arid areas.[3]
- Use equipment that is free of weed seeds.
- Sow a mixture of fast-germinating and long-lived grass or forage species tailored to the site (some local seed companies have reclamation specialists who can help)

- Sow at shallow depth into moisture for fast emergence.[3]
- Sow fertilizer with the seed.[3]
- Stop aggressive perennial weeds before they get a foothold - survey the site to see what is growing and get the weeds identified.

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4 Mechanical and Manual Methods

Mechanical and manual methods can be used to clear trees and brush, control weeds and brush regrowth, and maintain woody species at certain heights.

The selectivity of any mechanical method depends mainly on the vehicle's manoeuverability under the site conditions. Manual methods, on the other hand, are highly selective and thus are often used in environmentally sensitive areas.

In both clearing and maintenance of woody species, the regenerative ability of the species present is an important consideration. Many woody species can resprout or grow new suckers, as shown in Appendix E. Cutting or mowing these species may give rise to prolific regrowth. Conifers will regrow unless cut below the lowest branch.[1]

Mechanical Methods

Clearing Trees and Shrubs

Several methods are used for clearing trees from rights-of-way and larger areas:

- pushing trees down with a dozer blade mounted on crawler tractor ("walking down")
- cutting trees with a blade attached to a crawler tractor, and
- rotary mowing.

In choosing a method for removing trees or brush, site conditions such as the size of the area, rockiness, and size of trees are prime considerations, as are the cost and availability of equipment (see references in Chapter 10, "Clearing Methods"). From a future vegetation management perspective, it is important to recognize that the method and timing of work will influence subsequent vegetation on the site. For instance, if natural revegetation of ground cover is desired, rotary mowing or winter clearing by crawler tractor is preferable, as it avoids disturbance to the existing ground cover and soil. On the other hand, stumps and roots will remain and resprout.

The walking down method is most suitable for large trees. In winter, it will result in frozen trees split off above ground, with stumps and roots that can resprout remaining in the soil. At other times of year, roots and stumps may be dislodged, but soil tends to adhere to

them, making burning difficult. To remove roots and stumps, it is often best to clear in winter, pile and dispose of the debris, break the land (breaking disc or moldboard plow), prepare a seedbed, and seed.[2]

An angled side cutter blade (for example, a KG blade) is often used on a dozer for clearing rights-of-way and uneven terrain. A double V-blade can remove more trees and is better for large areas than a side cutter blade, provided the terrain is flat.[2] On rocky land, cutting blades or mowers cannot be used; walking down or manual methods may be necessary.

Rotary Mowing

Rotary mowing is used for clearing small trees and brush as well as for cutting grass and weeds. In clearing, it eliminates the need for piling and burning, as above-ground vegetation can be shredded by the mower given sufficient time. Rotary mowers range greatly in size.

Light roadside models are mounted on a boom from a tractor. The head can be tilted to fit the slope of the ditch. These are useful where broadcast spraying is not desired, such as near subdivisions. These mowers are also useful for large weeds in ditches such as kochia, which can be cut and later shredded in a second pass when dry.

"Brushaxes" (sometimes called "hydroaxes") are large rotary mowers that can cut and mulch trees up to 15 cm in diameter. They are often used for shrubs and regrowth on rights-of-way. The rotary head can be raised several feet and lowered onto a tree, removing the top. Fragments can be reduced to the desired degree of mulch. The remaining woody stubble is splintered and will resprout, necessitating foliar spraying after a year or two or removing at approximately 3-year intervals. The stubble may be treated with herbicide to prevent resprouting.

Brushaxes are available in several models and are available on tracks or rubber tires. Rubber-tired models can become stuck in snow or mud, sometimes creating deep ruts and erosion. Most brushaxes can operate on shallow slopes.

Clearing Regrowth

Small brush, being flexible, is best handled by cutting or mowing. Willows may be cleared by disc plow pulled behind a crawler tractor or by rotary mowing.[3] On large cleared areas with shrub regrowth, dragging heavy equipment which scrapes the bark of the regrowth may cause it to dry out and die. This appears to work best for brush which is 2.5 - 5.0 cm in diameter.[4] Further evaluations of this method are currently underway.[4]

Weed Control

Various models of handheld and ground-driven cutting and mowing machines are used for weed control. Some weeds can be more easily controlled than others by mowing. The ability of mechanical and competitive methods to control some common weeds of rights-of-way and other uncultivated areas is summarized in Appendix C.

Road shoulders and edges of paved areas are sometimes graded to control weeds. Extensive grading may cause shoulders to deteriorate. If streams are nearby, erosion from the loosened edges may present a hazard to water quality.

Manual Methods

Handslashing

Chainsaws or clearing saws (brush saws) are used when a high degree of selectivity is required. Clearing saws, which can handle stems up to 15 cm in diameter, are superior to chain saws for small-diameter stems, while chainsaws are best for larger stems. Most brush-cutting crews in the prairie provinces are experienced with chainsaws but not clearing saws.

Resprouting can be expected in many species if cutting is not followed by herbicide treatment (page 32). Clearing saws equipped with an automatic herbicide applicator are available for this purpose.

Girdling

Girdling is used for selective removal of large trees. It is effective on poplar as well as many other species. In this method, a ring of bark, the underlying cambial layer, and a slight amount of sapwood are removed below the lowest living branches (or the branches below the girdle can be severed). This kills the tree by preventing the flow of photosynthesis products from crown to roots. Complete mortality takes several years, and the dead trees remain standing for some time. In mature aspen stands, defoliation is almost complete two years after girdling. Root suckers may grow but soon die.[5] Because of the danger of falling trees, this method is not suitable for public areas. However, it could be useful in environmentally sensitive areas where access is difficult. Girdling is not suitable for trees that have many low branches and cannot be done under frozen conditions.

With tools for the proper size range, girdling is reported to be faster than the "hack and squirt" herbicide application method (page 32).[6] Special girdling tools are available for treatment of stems from 4 to 16 cm dbh (diameter at breast height). Above 16 cm dbh, a tool made from the chain of a chainsaw is reported to be fastest.[6]

Pruning and topping

Deciduous trees are normally pruned with a long-armed saw from an aerial bucket (air saw). Pruning is a costly method, as it must be repeated approximately every three years.

Conifers that have grown too tall may be topped, resulting in more growth of lateral branches and slow reattainment of height. Topping of deciduous and coniferous trees may result in an unattractive appearance for several years.

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5

Biological Control Methods

Biological Control of Weeds by Insects and Pathogens

Many aggressive, economically damaging weeds have come to Canada from other parts of the world without the insects or pathogens that normally keep them under control. Hence, introducing their natural insect enemies from the countries of weed origin is a possible means of control. A number of perennial species have been significantly reduced in abundance in this manner, including nodding thistle[1] and toadflax.[2] Insect agents are currently being tested in the prairie provinces for Canada thistle, toadflax, leafy spurge, and perennial sow thistle.

Biological control of weeds by insects is most suited to situations in which a single weed species is invading a large land area. With some weed species, the introduced insects have stressed, but not controlled, the infestations. Ultimate success sometimes requires more than one type of insect or a combination of biocontrol and other measures such as mowing.[3] On the whole, biocontrol has been more easily achieved where another environmental stress is present, such as aridity, as regeneration of plants following defoliation depends on the availability of moisture.[4]

Prior to instituting a new biocontrol program, an environmental impact assessment is conducted. The benefits and losses

attributable to the target weed species are weighed. All candidate insects are screened for potential effects on native plants, and an investigation is conducted into the reasons for their host specificity prior to release. Thirty insect species have been released in Canada with no serious non-target effects.[3]

To inquire about the possibility of a biological control program, consult the contact persons cited in Chapter 10. Populations of insects which have successfully controlled an infestation are often collected by farmers and extension personnel for distribution to other sites. After control has been achieved, a small, non-threatening population of the weed species is maintained in order to allow the continued survival of the insect control agent.

The development of weed control products ("bioherbicides") from fungi and plant pathogens which attack certain weed species in nature is a developing technology. Several bioherbicides are commercially available in the U.S.

Grazing

Grazing by domestic animals has been used for both weed and brush control. Sheep, goats, pigs, cattle, and geese have been used for this purpose. In any grazing program, the nutritional requirements of the animals must be considered.

Sheep are excellent non-selective grazers of weeds, consuming many broad-leaved species. Weed seeds are less likely to remain viable after passing through the digestive system of a sheep than a cow. Sheep have been used to control leafy spurge on western U.S. rangeland. On foothills rangeland in Alberta, a long-term study with 1,100 loosely herded sheep found that the animals removed about 40% of the broad-leaved forb production and 10% of grass production. Hairless species including tall larkspur and dandelion were selected preferentially.[5] Several passes of the sheep controlled regrowth of willow but not poplar on range, whereas sheep confined by fencing defoliated both small poplar and willow.[5]

Cattle can be used to control invading aspen on native fescue rangeland.[6] They will graze young suckers of aspen, wild rose and wild raspberry from June through August, although they will not utilize balsam poplar or western snowberry.[7] When using this method of control on native range, it is necessary to combine rotational cattle grazing with occasional mowing or spraying in order to avoid overgrazing native grasses.[6]

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* Available from Faculty of Extension, University of Alberta, Edmonton, AB T6G 2G4

6

Controlled Burning

Controlled burning is not a common method of clearing or brush control in Alberta. Single burns only topkill most woody parkland species, resulting in rapid regrowth from the roots.[1] However, some research has been conducted into the use of burning in combination with other methods in the parkland region. The findings of this research are described below, and further references are cited in Chapter 10.

For all controlled burns, proper timing, meteorological conditions, and operator experience are essential for successful results.[1]

Long-term studies have compared the cost and results of clearing large tracts of aspen parkland by two methods:

- spray and burn: foliar spraying of 2,4-D ester to kill top growth of aspen, followed by burning in the second year and seeding into the ash
- clear and break: winter clearing by dozer blade, piling, discing, repiling, and seeding.

The spray and burn method resulted in gradual mortality of aspen, reaching 80% three years after treatment.[2] The costs involved in preparation and treatment were less for the spray and burn than for the clear and break method ($130 vs. 443/ha, respectively, 1985 values)[3]. For establishing forage for cattle on rangeland, the spray and burn method appeared to be a profitable alternative to traditional clearing methods.[3]

Another means of clearing parkland is by cattle grazing following a prescribed burn. When managed, intensive grazing was allowed for two years after a burn, the amount of brush declined significantly.[1]

As a means of controlling invading brush on rangeland, a combination of burning followed by spraying of regrowth with 2,4-D for two successive years has been successful.[4]

Controlled burning can create good conditions for combined domestic and wildlife browsing of brush suckers.[1]

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7

Chemical Methods

A variety of products, application methods, and equipment is available for industrial and non-crop herbicide use. The responsible herbicide user aims at putting the "proper pesticide, in the proper concentration, on the target organism at the right time".[1]

Herbicide Selectivity

Herbicides are divided into two broad categories, **selective** and **non-selective**, on the basis of whether they control all or some plant species at registered application rates. Those which control all vegetation are referred to as **non-selective** (also "bare-ground herbicides" or "soil sterilants"). Those which control only some species are termed **selective** herbicides. Many selective herbicides control broadleaf (dicotyledonous) species only, although some control certain species of trees or grass among other species. When applied at higher rates, some selective herbicides become non-selective. Appendix F shows the selectivity of many widely used herbicides and their chief means of entry into plants (roots or leaves).

Plant species differ in their susceptibility to herbicides. Appendix A illustrates the different susceptibilities to herbicides of some woody species. The label on the herbicide container specifies the rates to be used and the recommended timing of application for each species for which the herbicide is registered.

Herbicide Formulations and Products

Herbicides come in a variety of forms, from wet to dry. Liquid formulations include water-soluble and emulsifiable concentrates and suspensions (the latter may be called "flowable"). Dry formulations include granules, pellets and wettable powders. In some cases, the active ingredient of the herbicide is available in several forms, enabling it to be applied in a variety of ways (see Application Methods below). Each formulation of an active ingredient has a separate commercial product name.

Combinations of herbicides are sometimes useful. Herbicides may legally be mixed only with those herbicides or other chemicals specified on the product label. Some premixed combinations are commercially available.

Application Methods

Foliar Application

Spraying of liquid formulations onto leaf (foliar) surfaces is the most commonly used method of application. The liquid formulations are generally diluted in water (the "carrier").

Ground broadcast

Conventional sprayers range from backpack to power-driven types and are equipped with a tank, pump and nozzle(s) and pressure regulator and gauges. **Backpack sprayers** are driven by compressed air and hold up to approximately 20 L of liquid. The hand-held boom or wand may have one or more nozzles. They are often used for inaccessible areas and environmentally sensitive areas such as streambanks where spot treatment is required.

Power-driven sprayers can be mounted on various kinds of vehicles, from trucks to trikes. They may have booms or a combination of equipment including a handgun for spot treatment. The potential exists for the applicator to overdose when using the handgun, as the amount delivered is difficult to gauge. This can

result in patches of dead grass or other non-target vegetation around the target site.

Special spray nozzles and devices such as **controlled droplet applicators** (spinning discs, rotary atomizers, etc.) designed to reduce drift are available. These devices can be used in higher wind speeds than conventional sprayers. However, they may give less leaf coverage and, for some herbicides, poorer results. Evaluation of the efficacy of these sprayer devices with various herbicides is ongoing.

Other technological advances in ground foliar application equipment include:

- ***Automatic flow monitors*** that adjust delivery rate to travel speed in order to maintain the desired rate of application. These also indicate volume pumped, area sprayed, and distance travelled.
- ***Multiple injection systems*** that inject undiluted herbicide and water as required into the sprayer line. By having several tanks, these enable spot application of a second herbicide or mixture and the re-use of left-over, undiluted herbicide. These systems are undergoing further refinement. Wettable powders, flowables, and water dispersible granules cannot be used.
- ***Hollow cone nozzles*** that reduce drift. As with controlled droplet applicators, evaluations with different herbicides are ongoing.

Aerial broadcast

Fixed or rotary wing aircraft are sometimes used for inaccessible or large areas. For spraying the perimeters of treated areas, the edges of stream buffer zones, and rights-of-way through forested areas, where conventional aerial spraying may pose a drift hazard, the helicopter-mounted **Microfoil boom** and a more recent modification, the **Thru-Valve boom** are useful. This type of spray boom reduces droplet drift substantially, as shown in studies by the Canadian Forestry Service (for further details see "Contacts" in Chapter 10). These booms require up to three times the water volume of conventional aerial spray equipment.

Roller and wick application

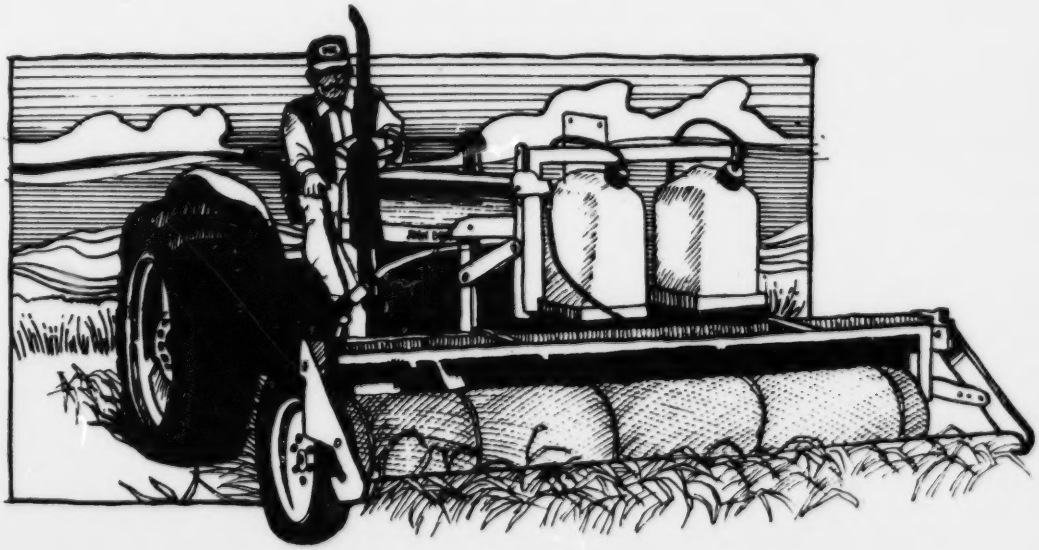
Roller and wick applicators employ a herbicide-soaked material to treat vegetation as it comes into contact with the wick. Since the wick can be set at various heights, lower-growing vegetation need not be treated. The wick applicator, suited for weeds in crops, utilizes a wick which soaks up herbicide from a reservoir. The more

rugged roller applicator is more suited for brush regrowth, utilizing a rotating carpet material onto which the herbicide drips. Low volumes are used; application rate increases with density of foliage. Little if any dripping and no drift occur, allowing use in or near sensitive areas. The applicators can be mounted on many types of vehicle and will operate on slopes. This method is suited for areas having widely dispersed target species (where blanket application would be wasteful) and for areas where lower-growing species are to be preserved.

These applicators have been used successfully in such diverse situations as:

- brush regrowth on right-of-way 2 years after rotary mowing[2]
- brush regrowth on pastures[3]
- streambank weed control (specially developed front- and side-mounted wick applicator booms[4]
- weed control on pastures using roller applicator, and
- weed control on foothills ranges (skidder-mounted).

At present this method can only be used on non-cropland in Canada with one herbicide, glyphosate, as no other herbicides are registered here for roller wiper application on non-cropland. No herbicides are registered for roller wiper use on rangeland. Treating brush in mid-to-late summer is reported to work best with glyphosate and this method.[3,5]



Bark (Basal) Application

Some herbicides will control small trees and brush when sprayed in a diesel or fuel oil carrier on woody stems. This method can be used during any season and is sometimes used after crop harvest to prevent damage to adjacent crops. Trees are sprayed from the ground to a height of 45 cm, encircling each stem. The same equipment is used as for ground foliar spraying, except that a basal wand is attached for individual stem spraying. Depending on the persistence of the herbicide used, nearby plants may be affected through runoff into the soil.

Regrowth of aspen (but not balsam poplar) can be treated on alfalfa pastures during the dormant stage with 2,4-D in oil without injury to the alfalfa.[5]

Stump Treatment

After handslashing, the remaining stump is often treated to prevent regrowth. 2,4-D and 2,4-DP, picloram, and glyphosate are some of the herbicides registered for this method. Most products must be applied within several hours of cutting, with the exception of a dichlorprop/2,4-D mixture containing a special penetrant for basal or delayed stump treatment. Resprouting stumps are treated from the ground up, including exposed roots. A dye is often included to mark treated stumps. Stump treatment is difficult to carry out in extremely cold weather.

Cut or Wound Injection

Individual trees can be eliminated by making a cut in the trunk and saturating it with herbicide. Cutting or "frilling" around the trunk may be done with a special hatchet with calibrated herbicide delivery system or with an axe and herbicide applied by squirt bottle ("hack and squirt" method). This method leaves trees standing and dead, an undesirable condition for areas of heavy public use. Root transfer of some herbicides may occur with poplar (see page 41).

A recent variation, which has received federal approval in principle because of its environmental safety, is capsule injection of a gelled form of herbicide into the trunk of immature trees (up to about 20 cm diameter). The capsule is inserted with an adapted drill and is said to be "tamper proof".[6] No capsule product has been registered for use to date, but efficacy data for its use with glyphosate are being gathered. The method can be used to within 1 m of water in some provinces. It avoids both the worker and ground contamination potential of other similar methods. Trees remain standing. It cannot be used on frozen trees.

Soil Application

Herbicides that are absorbed mainly through the roots of plants are sometimes referred to as "soil-active." Some of these herbicides are selective and others non-selective, as shown in Appendix F. They may be available in solid, wettable powder, and/or liquid formulations.

Solid formulations are applied without a liquid carrier and consist of granules and pellets, the former usually smaller and the latter larger than 10 mm³. Dicamba, picloram and tebuthiuron are some herbicides available in solid formulation. These are applied directly from the box as a spot treatment or broadcast via cyclone seeder or helicopter. Precipitation or watering is needed to carry them into the soil; otherwise, they may become dusty and subject to wind erosion. Round pellets have been known to roll down steep slopes. Granules and pellets can be applied any time after spring run-off and before ground freeze-up. When using these products, keep in mind that:

- Roots of trees extending into treated areas will pick up the herbicides. A general rule of thumb is to keep treatment one and one-half tree lengths from desirable trees.
- As with spraying, the height of affected trees must be taken into account, as foliage "brown-out" will follow.
- They should not be used near high water tables.
- Dry forms of non-selective residuals will kill grass as well as other vegetation in a spot around the site of application.
- On slopes, non-selective elimination of all vegetation and retarding of regrowth by residuals will lead to erosion problems.

Growth Retardants

Trees

A method of slowing tree growth by pressurized injection of growth regulators is presently used by the electrical utility industry in the United States and on an experimental basis in Canada. Its main use is to lengthen the tree trimming cycle.

Grass

Several plant growth regulators are available in Canada for inhibiting the growth of grass. Control of leaf growth and seed head production lasts between one and two months. Because the growth of different grass species is inhibited to different degrees, treated areas having several species may become unkempt in appearance. The major use of these products is considered to be hard-to-mow areas. The treated grass may become less dense and as a result, more susceptible to weed invasion.

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8

Chemical Precautions

This section describes conditions which promote offsite pesticide movement and measures that can be taken to avoid its occurrence. The toxicity of commonly used industrial and non-crop herbicides and fungicides to biological organisms is also discussed.

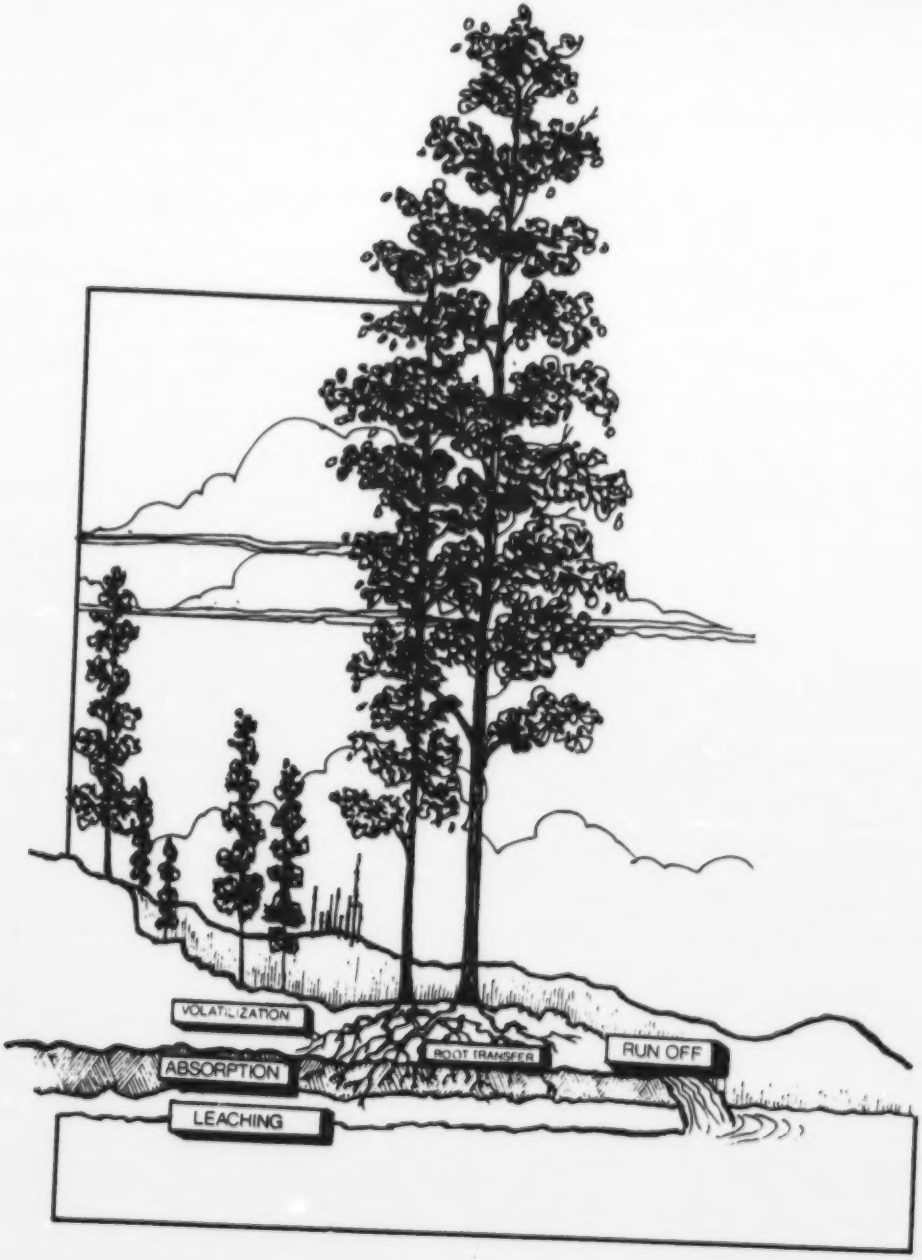
Environmental Safety of Herbicides

All pesticide products sold in Canada must be registered for use under the federal Pest Control Products Act. Registered pesticides likely to be consumed have been tested by the manufacturer for short and long-term health effects on test animal species, in order to assess animal and human risks associated with the product, and for their behaviour and fate in the environment. Other information regarding efficacy, laboratory analysis, and detoxification methods must also be provided by the registration applicant. If these test results are deemed acceptable by Agriculture Canada, in consultation with other federal departments including Environment Canada, the product is granted registration. After entry into the marketplace, pesticide products may be further monitored with regard to environmental and health effects. If a pesticide is found to be having adverse effects, its use may be restricted or registration withdrawn. As well, old pesticide products are gradually being re-evaluated.

The pesticide product label is a legal document whose wording reflects the results of these tests. It describes how the product is to be applied; any application not in accordance with this is illegal. It also states any precautions necessary to ensure environmental protection when using the product. When planning to use a herbicide or fungicide, always read the label for these precautions.

Applicator Restrictions

There is no restriction under the federal Pest Control Products Act on who may apply pesticides on federal land. However, provincial legislation restricts the application of certain pesticides (which may vary from province to province) to provincially licensed applicators. While this legislation does not apply to federal lands, every effort should be made to meet a province's requirements when applying a herbicide or fungicide to federal lands within that province. For advice on proper pesticide application, contact your district or regional office of Environment Canada, who will be able to provide assistance.


VOLATILIZATION
ABSORPTION
ROOT TRANSFER
RUN OFF
LEACHING

Off-site Movement

Not all pesticide applied ends up where it was intended. Not all spray entering the air falls on target vegetation - some falls on soil and some may be carried by air currents to non-target vegetation. Not all pesticide remains where it lands - some may be transported from leaves and soil by rain or wind to another site.

The major processes by which pesticides may be diverted or transported from the intended target to non-target sites are **drift**, **leaching**, **run-off**, and **root transfer**. An awareness of these processes, described below, will help you avoid them.

Drift

Types of drift

Herbicides may be transported aerially, during or after application, by several means:

Droplet drift. During application, air currents may carry the spray droplets onto adjacent areas. This loss usually amounts to less than 8% of the chemical applied by ground.[1] Conventional fixed-wing aerial application may result in drift losses of 30% or more.[1] Even with less than 5% droplet drift, there can be a hazard to off-site susceptible vegetation.[2] This is especially true with some of the newer herbicides such as the sulfonylureas, which are active in the parts per billion range of concentration.

Wind speed and direction. Droplet drift increases in direct proportion to wind speed. Wind speed cut-off limits often recommended to avoid drift damage to adjacent areas are:

- 20 km/h for ground spraying
- 10 km/h for conventional fixed-wing spraying.[3]

Under totally calm inversion conditions, a cloud of small spray droplets will often hover rather than settle on plant surfaces and will move away when a breeze develops. Thus, spraying when the wind is very light is best. If the wind is blowing steadily away from sensitive adjacent areas, you can take advantage of it to keep herbicide drift away from sensitive areas.

Vapour drift. After application, herbicides may evaporate from soil and leaf surfaces and be carried off by air currents. Gaseous herbicide may not settle out for a considerable distance. This phenomenon may occur within a few days after application[1] and is most likely when temperatures are high. Avoid spraying when very high ambient temperatures are expected, as these will cause even low-volatile herbicides to volatilize. Amine formulations have the lowest tendency to vaporize, followed by the long-chain ester formulations (such as the iso-octyl ester or propylene glycol butyl

ester). Short-chain esters, the most likely to vaporize, were phased out in the 1970s.

Wind erosion. Herbicides applied to soil, especially granular forms, require some precipitation to carry them down into the soil. If arid conditions prevail, they will remain in the topsoil layer and be subject to wind erosion.

Operating conditions to reduce drift

Droplet drift can be reduced by certain operating conditions and equipment.

Conventional spray equipment produces a spectrum of droplet sizes. The smaller the spray particle, the more potential for drift. Production of small, driftable droplets when ground spraying can be reduced and the proportion of large droplets increased by some simple changes to equipment. These include:

- ***lower hydraulic spray pressure***- Use of 240-300 kPa with flat-fan nozzles will lower drift potential. Special, inexpensive 80-02 LP (low pressure) nozzles at 100 kPa result in less than 1% drift in a 20 km/h wind.[3]
- ***high water volumes*** such as 90-110 L/ha
- ***lower boom height***- 80-degree or 110-degree spray angle nozzles which allow boom height to be 10 and 20 cm closer to the target plants, respectively, will result in less drift than the 65-degree nozzle.[4]

Measures which will reduce drift from conventional aerial spraying equipment include:

- use of coarser spray nozzles
- pointing spray nozzles away from the wind stream to reduce the sheer force on droplets exiting nozzles
- lowering height of release
- lowering release pressure
- lowering flight speed, and
- applying pesticide under cool, humid conditions.[5]

Special drift-reducing devices such as controlled droplet applicators, hollow-cone nozzles and the Microfoil and Thru-Valve Boom have been described in Chapter 7. Other products which reduce drift are:

- ***Boom shrouds*** for field-type sprayers. These surround the spray boom and nozzle, thereby confining droplet drift. They can reduce

droplet drift to less than 1%.[3] Their effect on application rates is under evaluation.

- ***Drift-reducing additives*** such as foams and thickeners. These are available for control of droplet and vapour drift in ground and aerial application. Some of these products may result in poor coverage and poor on-swath deposit uniformity.[3] They should be used only if specified on the herbicide label or after checking with the herbicide manufacturer.

Leaching

Leaching, the downward movement of a chemical through the soil profile, is beneficial when control of deep-rooted plants is required, but can be a problem if roots of non-target trees or a shallow water table are present. Non-target tree die-off from this effect can be observed along highways throughout Canada. The effects of leaching may not become apparent for over a year with some herbicides.

Herbicide leaching is partly a function of soil type. Prairie soils are generally conducive to leaching, as their alkalinity reduces the soil's capacity to bind herbicides. This is particularly the case with acidic herbicides, such as 2,4-D, dicamba, and picloram. Most herbicides bind most strongly to soil containing organic matter or clay and least strongly to sandy soil. Herbicides which leach readily should not be used on sandy soil overlying a shallow water table. Non-chemical methods of vegetation control may be better suited to such areas.

The extent to which a herbicide leaches is also dependent on its water-solubility and the amount of water available. The leaching potential of some herbicides under typical parkland conditions is shown in Appendix B.

Run-off

Some herbicides may be washed from vegetation if rain falls soon after application. The herbicide residue may then be carried in surface run-off to receiving waters. Relatively heavy concentrations have occasionally been measured in receiving waters after heavy storms within 1 to 2 weeks after application. This herbicide pulse is short-lived and quickly diluted in large, fast-moving streams, but can be hazardous to aquatic life in small watercourses or stationary bodies of water.

The highest run-off potential occurs on

- untilled, compacted soils
- slopes, and
- other areas with soil erosion.

A strip of vegetation about 25 m wide can greatly reduce herbicide run-off concentrations by taking up the herbicide.[6] For this reason, buffer zones of unsprayed vegetation adjacent to waterbodies are required by provincial legislation. The width of such zones is generally 30 - 50 m.

Other ways of avoiding run-off into shallow water tables and waterbodies are:

- use of any measures that restrain water run-off and/or soil erosion
- use of non-chemical alternatives
- use of very selective herbicide methods such as capsule injection, frilling, stump treatment, girdling
- use of alternatives to formulations with high run-off potential
- avoiding blanket foliar application when leaves are still wet from rain or if rain is expected.

At some facilities, drainage tiles may have been installed to carry subsurface run-off to a creek or watershed. This possibility should be checked before application of a herbicide.

Root Transfer

In clonal species such as poplar, systemic herbicides may move through connected roots to another tree in the same clone. This may occur after spraying or stump treatment. It is sometimes referred to as "flashback" or "backflash." Herbicides that may move through roots in this way include: atrazine, dicamba, picloram, triclopyr, clopyralid, hexazinone, and simazine.

Herbicide Persistence

Herbicide persistence is advantageous when long-term control is required, provided the herbicide remains on site. If it moves off site or remains active past the time period desired, residue problems may ensue. For instance, piled soil treated for weed control on vacant lots, if used for landscaping before the herbicide has become inactive, will result in problems with revegetation. In such a case, a shorter-lived herbicide should have been chosen.

Among the ways in which herbicides become inactivated in the environment, microbial breakdown is a major means. Breakdown processes are fastest in warm, moist soil. In the cool, semi-arid climate of the Canadian prairies and parkland, many herbicides persist for longer periods than in other climates.
The relative persistence of some herbicides is shown in Appendix B. Granular formulations tend to be more persistent than other formulations.

Repeated yearly application of short-lived herbicides does not appear to have resulted in soil build-up of these chemicals. Yearly application of 2,4-D to Saskatchewan soil for over 35 years has not resulted in accumulation.[7] On the other hand, repeated yearly application of residual herbicides can lead to soil build-up. On vegetation-free areas, avoid this problem by using the alternative measures listed on page 12.

Toxicity to Animals

Herbicides

Herbicides are much less toxic than insecticides to most animals. However, some herbicides are toxic to fish and invertebrates.

Honeybees

Most herbicides are not directly toxic to bees, with the exception of those noted below. Of course, preventing plants from blooming - by any control method - diminishes forage for honey bees and other ecologically important pollinating insects. The ecological significance of this loss depends on the availability of other sources of forage in the area.

Although little research on toxicity to bees has been conducted in Canada, research in the U.S. has shown that high dosages of

amine formulations of 2,4-D are toxic to honey bees.[8] Butyl derivatives of 2,4-D may also be toxic to bees over the long term when used near plants on which bees forage.[8] The oil in oil-based herbicide sprays is also toxic to bees.[9] Moderate toxicity from desiccants such as paraquat and simazine have been reported.

Direct contact with honeybees can be avoided by spraying when they are in the hive, which is when the temperature is relatively cool. Cool, late evenings are safest. Cool, early mornings are second best, as there is less time after application for the spray to dissipate before foraging begins. Consider your timing when using the following herbicide products on weeds or crops that are in bloom:[8]

- amitrole
- certain formulations of 2,4-D (alkanolamine, isopropyl ester, or butoxyethanol ester- Weedone LV4)
- bromacil (Hyvar X), and
- simazine.

Aquatic Organisms

Some herbicides commonly used in noncrop areas are acutely toxic to fish and to aquatic insects and crustaceans, which are food for waterfowl and fish.

- Esters of 2,4-D are highly toxic to fish, crustaceans and aquatic invertebrates.[10] The isooctyl ester and dimethylamine forms of 2,4-D in diesel oil are toxic to rainbow trout.[11] Young fish are more sensitive to 2,4-D than adults, and herbicide concentrations in run-off occurring soon after herbicide application may occasionally endanger younger fish.[12]
- Different formulations and grades of picloram appear to be of differing toxicity to fish.[13] In heavy run-off situations, picloram can be injurious to young cutthroat trout.[14]
- Glyphosate-containing herbicide products have been reported by some to be injurious to fish.[15]
- Atrazine and simazine are harmful to types of aquatic insects used as food by ducks.[16]

Turf Fungicides

Turf fungicides may contain a number of different active ingredients, many of which are toxic to fish and wildlife. Some contain mercury salts which are poisonous to earthworms and to birds which eat the worms.

Clean-up and Disposal

The outcome of a herbicide treatment and off-site effects may be quite different than intended if the sprayer tank is not cleaned out adequately between uses of different chemicals. After draining the sprayer tank, wash all equipment parts, including hose, nozzles, and tank. The wash water should be agitated while cleaning. The procedures and solutions required for different types of herbicides vary; consult the label and also provincial agriculture weed control personnel. (See also references in Chapter 10 "Pesticide Handling"). Dispose of the wash water away from watercourses, dugouts, wells, and susceptible vegetation.

Improper disposal of used containers can lead to contamination of aquatic environments. The best means of disposing of used containers is by the special treatment processes established in some provinces. Otherwise, label instructions for disposal should be followed. Whatever the container disposal method, containers should first be triple-rinsed with water and the rinse water returned to the tank for use.

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13. Mullison, W.R. 1983. A Toxicological and Environmental Review of Picloram. Dow Chemical Co. Midland, Michigan. 49 pp.
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9 Developing a Vegetation Management Plan

Perhaps you have inherited a vegetation management program or are in charge of a site that is undergoing development. This chapter is designed to help you tailor a vegetation management program specifically to the site, whether it is about to be developed or already established.

Established Sites

The vegetation needs of an established area are not static. Vegetation changes over time, as may objectives for the area, making it necessary to reassess management requirements periodically. This section deals with vegetation management on sites which are already well-vegetated and are not undergoing a great deal of site disturbance.

Defining the Situation

To clarify the current vegetation management needs of the site, answer the following:

Primary objectives

- What are the vegetation requirements for the primary use of the site?
  (If they include control of noxious weeds, what are the province's noxious weeds? - each province has its own list.)
- Where will each type of vegetation identified above need controlling?
- Are some species of this type acceptable and others not? (for example, tall-growing vs. short-growing trees under a powerline)

Secondary objectives

- Could/should the site provide public recreation, grazing for wild or domestic animals, or other uses in addition to its primary function?
- Are there certain times when the public uses some of the area? Is this use compatible with the primary use of the site?
- Do these secondary uses require any further vegetation control?
- Are there adjacent land uses such as farming, residential, commercial forest management areas, etc?
- Are there environmentally sensitive areas within or adjacent to the site which may require special treatment?

Examining the Site

In order to answer some of these questions, you will need the following information. Some of it can be obtained from a brief visit to the site. Other sources of this information are aerial photographs and professional personnel (biological, agricultural) in the area.

- **location of**
  a) slopes
  b) streams, ponds, lakes, intermittent watercourses
  c) muskeg and wetland areas, natural areas
- **presence of high water table**
- **soil texture - sandy, clay, loam**
- **adjacent land use(s)**
  a) park: Is it a high visibility area?
  b) agricultural: What crops are adjacent? noxious weeds? which species?
  c) forest: Is it adjacent to commercial timber stands?
  d) residential: Where are the shelterbelts, gardens, houses?
- **wildlife areas**: travel corridors linking river valleys, other natural areas important to wildlife - these can be identified by local government biologists
- **target plant species present, approximate density and proportion of total vegetation present** (agricultural extension personnel can identify weed species in their early stages)
- **major types of non-target plants present and approximate density**

This information can be made into a baseline document, which might include a diagram or map of important features and where each method is to be used, for future reference by yourself, future managers, contractors and work crews.

Examining the Options

Once you have taken a close look at all objectives for the site and conducted a site inventory, you will be able to identify any land use or environmental constraints and plan the timing for your treatment(s).

- What is the best height/growth stage at which the target species should be controlled?
- Will the secondary objectives identified (if any) affect the choice of vegetation control methods?
- What land uses or environmentally sensitive areas may require special precautions when controlling nearby vegetation?

Identify any methods which appear potentially useful for a portion or all of the site. These methods can now be compared with regard to cost-effectiveness for the target species and availability of equipment/ labour. Local agricultural personnel and vegetation control guides can provide this information.

Informing the Public

In cases where the area is used by the public, it is important to inform likely user groups of the need for control work and the timing and nature of the intended work. Failure to do so has sometimes resulted in public misunderstanding and opposition to the work.

Record-keeping and Evaluation

Monitor and record the results of control work done. Only in this way can you learn what works best and know when to initiate the next treatment.

Records of the work done might include:

- areas treated and date
- materials, methods, equipment, crew
- costs
- environmental conditions
- problems
- results.

The results will reveal over the years how effective each method is, the long-term costs, problems and best solutions.

Newly Developed Sites

A newly developed site requires additional planning but offers the opportunity for setting up relatively easy-to-manage vegetation. Becoming involved in the pre-construction planning phase is the first important step. By participating in this phase, you may save on long-term vegetation maintenance costs. For instance, siting facilities away from sensitive areas may eliminate the need for special vegetation management methods.

Pre-construction Planning Phase

The following steps should be undertaken in this phase:

- Check the intended location of facilities against the physical and environmentally sensitive features of the site to avoid any future need for special vegetation maintenance measures and permits.
- Delineate and minimize the areas of soil disturbance. These areas may need reseeding and will likely be weedy.
- Plan for erosion control, using natural watercourses for drainage where possible.

Vegetation Management Planning Process

- If residual herbicides are going to be used around a facility, plan berms for catching run-off water. These should extend into the soil for some distance to catch any subsurface run-off of chemicals.
- Ensure that slopes of access road rights-of-way and other relevant facilities are designed to allow the option of mowing.
- Note future land use if land reclamation is intended.
- If revegetation is required, choose seed mix and seeding method based on site characteristics (soil type, climate). Some seed companies have reclamation consultants who can help with this selection. Regional recommendations for seed mixes may also be available from the provincial forestry or public lands agencies. Request a weed seed analysis for the seed chosen and check the results with local agricultural personnel to ensure that the seed does not contain species of noxious weeds that are new to the area.

Post-construction Phase

At this stage it is important to prevent unwanted species from becoming established. In addition to the steps below, use the preventive measures listed on page 17.

- Replace topsoil, seed immediately (include fertilizer), mulch if necessary.
- Inspect for germination and undesirable vegetation that will require control.
- Formulate a vegetation management plan as described for established sites above.
- Record methods used and success for future reference.

10 General References

Contacts

National Pesticides Call Line

(1-800-267-6315)
This public service is maintained by Agriculture Canada to answer questions related to pesticides and their use (such as registered uses, safety questions, side effects, etc). The service responds in a quick and courteous manner to a broad range of inquiries. Highly technical inquiries are referred to the best sources of information. It does not handle emergency poisoning information nor make recommendations regarding use.

Environmental Protection Offices Conservation and Protection Service, Environment Canada

Regional Office, Western and Northern Region
4999 - 98 Ave., Edmonton, AB T6B 2X3 (403)468-8040

District Offices

Alberta District Office
4999 - 98 Ave., Edmonton, AB T6B 2X3 (403)468-8001

Saskatchewan District Office
1901 Victoria Ave., Regina, SK S4P 3R4 (306)780-6464

Manitoba District Office
269 Main Street, 5th floor, Winnipeg, MB R3C 1B2 (204)983-2961

Northwest Territories District Office
Box 370, Yellowknife, NWT X1A 2N3 (403)873-3456

Provincial Environment Departments

Alberta Environment, Waste and Chemicals Division, Pesticide Chemicals Branch, 9820 - 106 St., Edmonton, AB T5K 2J6 (403)427-5855

Saskatchewan Dept. of Environment, Air and Land Protection Branch, Chemical Management Section, 3085 Albert Street, Regina, SK S4S 0B1 (306)787-6185

Manitoba Dept. of Environment and Workplace Safety and Health, Environmental Management Services, 139 Tuxedo Avenue, Winnipeg, MB R3N 0H6 (204)945-7082

Provincial Agriculture Departments

Alberta Agriculture, Plant Industry Division, Crop Protection Branch, Weed Control Section, 7000 - 113 Street, Edmonton, AB T6H 5T6 (403)427-7098

Saskatchewan Agriculture, Soils and Crops Branch, Crop Protection Section, Walter Scott Bldg., Regina, SK S4S 0B1 (306)787-4673

Manitoba Department of Agriculture, Agricultural Development and Marketing Division, Soils and Crops Branch, Weeds Section, 908-401 York Avenue, Winnipeg, MB R3C 0P8 (204)945-3814

Canadian Chemical Companies

(1-800 - toll-free numbers for technical representatives)

BASF 1-800-661-9245

Chipman 1-800-661-1348

Ciba-Geigy Canada Ltd. 1-800-661-1532

Cyanamid of Canada Inc. 1-800-387-5073

Dow Chemical Canada Inc. 1-800-661-6436

DuPont Canada Inc. 1-800-667-3925

Elanco Products Division, Eli Lilly Canada Inc. (403)436-6131

Hoechst Canada 1-800-667-5959

May & Baker Canada Inc (416)821-4450

Monsanto Canada Inc. (204)885-6740

Pfizer Chemicals & Genetics Inc. (204)885-7752, (519)681-2173

Rohm & Haas 1-800-665-1250

Sandoz Agro Canada Inc. (416)821-7850

Biological control of weeds

Two government research centres conduct work on biocontrol of weeds: the Agriculture Canada Research Station at Regina and the Alberta Environmental Centre at Vegreville. The persons to contact are:

Dr. Peter Harris, Research Scientist,
Agriculture Canada Research Station
Box 440
Regina, SK S4P 3A2
(Many publications on biocontrol available)

Dr. Alec McClay, Research Scientist,
Alberta Environmental Centre
P.O. Bag 4000
Vegreville, AB TOB 4LO.

Reference Material

Vegetation Identification

Alberta Agriculture. Weed Seedlings of Alberta. Publ. no. 640-3 (some colour photographs).

Alberta Environmental Centre and Alberta Agriculture. 1983. Weeds of Alberta. 209 pp. Available from the Bookstore, Provincial Museum of Alberta, 12845-102 Avenue, Edmonton (Colour photographs of each species, including seedling stage).

Corn, I.G.W. and R.N. Annas. 1986. Field Guide to Forest Ecosystems of West-Central Alberta. Northern Forest Centre, Edmonton, AB. (Some colour photographs).

Inkpen, W. (no date). Guide to the Common Native Trees and Shrubs of Alberta. Alberta Environment, Pesticide Chemicals Branch. 55 pp. (Contains colour photographs and simple diagrammatic key; rates values of native trees and shrubs for types of wildlife.)

Looman, J., W. Majak and S. Smoliak. 1983. Stock-poisoning Plants of Western Canada. Agriculture Canada, Research Branch. 35 pp. Available from Agriculture Canada Research Station, Box 1030, Swift Current, SK S9H 3X2. (Describes distribution and habitat of poisonous species and symptoms of poisoning. Drawings and photographs.)

Vegetation Control – General

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Alberta Agriculture. 1983. Weed Control in Alberta. Part IV: Weed Species. Crop Protection Branch, Edmonton, AB.

Anderson, W.P. 1983. Weed Science. 2nd ed. West Publishing Co. St. Paul, Minnesota.

Stearman, W.A. no date. Controlling Brush in Alberta. Agdex 643-2. Alberta Agriculture, Crop Protection Branch, Edmonton, AB. 23 pp.

Herbicides

Adams, R.W. 1987. Handbook for Pesticide Applicators and Dispensers. B.C. Min. of Environment and Parks. Fifth Edition. 248 pp. Available from Queen's Printer, Parliament Bldg, Victoria, B.C. (Provides valuable information on pesticides and their safe and environmentally sound application).

Alberta Agriculture. 1988. Guide to Crop Protection in Alberta 1988. Pt I: Chemical. Agdex 606-1. Crop Protection Br., Edmonton. (Updated yearly).

Alberta Agriculture. 1986 (revised). Recognizing Herbicide Injury and Action. Agdex 641-7. Available from Print Media Branch, Alberta Agriculture, Edmonton.

Footz, T. 1986. Guide to Crop Protection in Alberta. Part III. Pesticide Application Equipment. Agdex 744-5. Alberta Agriculture, Crop Protection Branch, Edmonton. 57 pp.

Saskatchewan Agriculture. 1988. Chemical Weed Control in Cereal, Oilseed, Pulse and Forage Crops, 1988. Agdex 641. Soils and Crops Branch. (Updated yearly).

Weed Science Society of America. 1983. Herbicide handbook of the Weed Science Society of America. Fifth ed. WSSA. 515 pp. Available from WSSA, 309 West Clark St., Champaign, Illinois 61820. (Contains detailed information on use, behaviour, and toxicology of all herbicides registered in the U.S.)

Fungicides for Turf

Ware, G. W. 1988. Complete Guide to Pest Control – With and Without Chemicals. 2nd ed. Thomson Publications. Fresno, CA.

Clearing Methods

Harder, G.L. and A.G. Taylor. In press. Land Development: A Guide to Clearing, Piling, Breaking and Working Down Land in Northwestern Alberta. Public Lands Division, Alberta Forestry, Lands and Wildlife.

Controlled Burning

Wight, H.A. and A.W. Bailey. 1982. Fire Ecology - United States and Southern Canada. John Wiley & Sons. N.Y. ("Prescribed Burning", Chapter XVI).

Pesticide Handling

Alberta Agriculture. 1986. Sprayer cleanout. Agdex 744-7. 1p. Available from Print Media Branch, Alberta Agriculture, 7000 - 113 St., Edmonton, AB T6H 5T6.

Health and Welfare Canada. 1984. Pesticide Handling: A Safety Handbook. Supply and Services Canada 1987. Cat. no. H31-12/1987E.

Pesticide Suppliers and Laboratories

Clutton, E., ed. Pest Control Canada. PACS, Burlington, Ontario. (Lists Canadian manufacturers, suppliers, and distributors. Also lists Canadian laboratories which conduct residue testing in soil, water, etc.)

Reclamation and Wildlife Habitat

PRISM Environmental Consulting Services Ltd. 1984. Habitat Enhancement and the Petroleum Industry. Canadian Petroleum Association, Calgary. 70 pp. (Presents easily implemented wildlife habitat enhancement methods for linear developments.)

Green, J.E. and R.E. Salter. 1987. Methods for Reclamation of Wildlife Habitat in the Canadian Prairie Provinces. Prep. for Environment Canada and Alberta Recreation, Parks and Wildlife Foundation by the Delta Environmental Management Group Ltd. 114 pp. Available from Communications Branch, Environment Canada, Western and Northern Region, 4999-98 Avenue, Edmonton, AB T6B 2X3. (Covers many aspects of planning and implementing wildlife reclamation work.)

Prairie Farm Rehabilitation Administration. no date. Planting trees for wildlife habitat. P.F.R.A. Indian Head, SK. 12 pp.

Watson, L.E., R.W. Parker and D.F. Polster. 1980. Manual of Plant Species Suitability for Reclamation in Alberta. Vol I: Grasses; Vol II: Forbs, Shrubs and Trees. Alberta Land Conservation and Reclamation Council, Edmonton. Rept #RRTAC 80-5. 550 pp. (Much useful information on each species: nutrient requirements, grazing and mowing tolerance, value for erosion control. Describes palatibility and nutritive value of grasses, shrubs and trees to native wildlife and domestic animals.)

Appendices

Appendix A. Susceptibility of Woody Species to Some Herbicides*

Species		2,4-D	picloram	dicamba+ 2,4-D	glyphosate
alder	*Alnus* spp.	s	s	s	s
ash, mountain	*Sorbus* spp.	r	i	i	
birch	*Betula* spp.	s	s	s	s
cherry	*Prunus* spp.	s	s	s	s
cottonwood, black	*Populus trichocarpa*	i	s	i	s
currants	*Ribes* spp.	r	s		
dogwood, red osier	*Cornus stolonifera*	i	s	s	s
elderberry	*Sambucus* spp.	s	s	s	s
fir, balsam	*Abies balsamea*	r	s	i	s
hazelnut	*Corylus* spp.	s	s	s	
pine	*Pinus* spp.	r	s	i	i
poplar, aspen	*Populus tremuloides*	i	s	s	s
poplar, balsam	*Populus balsamifera*	i	s	s	s
raspberry	*Rubus* spp.	r	s		s
rose, wild	*Rosa* spp.	r	s	s	
saskatoonberry	*Amelanchier alnifolia*	s	s	s	
snowberry, western	*Symphoricarpos occidentalis*	i	s	s	s
spruce, black	*Picea mariana*	r	s	i	
spruce, white	*Picea glauca*	r	s	i	
willow	*Salix* spp.	s	s	s	s

(Modified from Miller 1984 and Monsanto Canada Inc. and Velsicol Canada Inc. product labels)
* Herbicides applied as a foliar spray
s = sensitive; i = intermediate (may be controlled at higher rates than susceptible species); r = resistant

Appendix B. Herbicide Behaviour in the Environment*

Herbicide	leaching potential	run-off potential	persistence
atrazine	M	H	H
borax	M	H	H
bromacil	H	H	H
chlorsulfuron	M		H(3)
dicamba	H	H	M-H
dichlorprop	L	H	L
2,4-D	L	H	L
diuron	L	L(1)	M-H
glyphosate	nil	L-M(2)	L-M(4)
hexazinone	M	M	M
MCPA	L	H	L
metsulfuron methyl	M		H(3)
paraquat	nil	L(2)	H(4)
picloram	H	H	H
simazine	M	H	H
TCA	H	H	M
terbacil	M	H	H
triclopyr	M	M	M

L=low M=medium H=high

*Assumes non-crop rates, little tillage, low organic matter, and alkaline soil

(1) except high on sandy soil
(2) bound to soil particles
(3) on clay
(4) does not persist in phytotoxic form

Appendix C. Mechanical, Competitive and Biological Weed Control Methods*

Species	Competition/Grazing	Mechanical	Insect Biocontrol
Bladder Campion	Do not fertilize. Proliferates in perennial vegetation.	Repeated mowing is effective.	
Canada Thistle	Alfalfa plus mowing 2x/yr.	Mow 2-3x/season for several years.	Being Developed
Common Tansy	Sheep can control.	Mowing before seed set. Cultivation will control.	
Dandelion	Fertilize. Reseed if possible.	Mowing not successful.	
Field Bindweed	Dry areas: crested wheatgrass; dense alfalfa + cr. rd. fescue or brome will control (not kill).	Mowing will help but low plants will escape.	
Flixweed	Fertilize. Reseed if possible.	Mowing will help but low plants may escape.	
Kochia		Mow as early as possible.	
Leafy Spurge	Intensive sheep grazing can control. Alfalfa or alfalfa/grass mix may stop spread but will not reduce size of stand.		Being Developed
Nodding Thistle	Dense grass will resist invasion. Do not fertilize the weed.	2-3 mowings/season will kill.	Available
Perennial Sow Thistle	Close grazing can control. Grazed by most livestock.	Mowing will not eradicate. Cultivation necessary.	Being Developed
Scentless Chamomile	Vigorous grass will outcompete.	Frequent shallow tillage. Mowing is inadequate.	
Stork's Bill	Dense forage will reduce weed's density.	Mowing not effective.	
Toadflax	Dense crested or intermediate wheatgrass or downy brome.	Mowing helps but doesn't eliminate.	Available
White Cockle	Most dense growth will outcompete. Do not fertilize.	Cultivate frequently deep enough to shear off crown.	

*Adapted from: Alberta Agriculture. 1988. Weed Control in Alberta. Pt II (Cultural). Crop Protection Branch, Edmonton.
Alberta Agriculture. 1983. Weed Control in Alberta. Pt IV (Weed Species). Crop Protection Branch, Edmonton.*

Appendix D. Growth Habits of Some Common Weeds

annual	winter annual	biennial	perennial
kochia	flixweed	flixweed	bladder campion
Russian thistle		diffuse knapweed	field bindweed
scentless chamomile		nodding thistle	sow thistle
		scentless chamomile	toadflax
			curled dock
			leafy spurge
			Canada thistle

Appendix E. Potential for Regrowth of Woody Species

Tree/Shrub	Regrowth
Alders	yes
Aspen	yes
Balsam Poplar	yes
Birch	yes
Buffaloberry	yes
Cottonwood	yes
Pin Cherry	no
Pine	no
Red-osier Dogwood	yes
Spruce	no
Tamarack	no
Wild Rose	yes
Willows	yes
Wolf Willow	yes

Appendix F. Herbicide Classification

Chemical class	Examples	Chief Mode of Selectivity	Entry
aliphatic acids	dalapon, sodium salt of TCA	S	F,R
benzoic acids	dicamba	S	F,R
bipyridyliums	paraquat	NS	F
phenoxy	2,4-D, 2,4-DB, dichlorprop, MCPA, MCPB	S	F
phosphonoalkyls	glyphosate	NS	F
picolinic acids	picloram, clopyralid	S	F,R
substituted ureas	diuron, linuron, monuron, tebuthiuron	S @ low rates, NS @ high rates	R
sulfonylureas	chlorsulfuron, metsulfuron methyl	S	F
triazines and triazoles	hexazinone, atrazine, simazine, amitrole	S @ low rates, NS @ high rates	R

S=selective, NS=non-selective, F=foliar, R=root